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Randomized evaluation of CDC HEADS UP concussion education materials for youth sport coaches

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Abstract

The Centers for Disease Control and Prevention (CDC) HEADS UP youth sports coach materials are the most widely adopted form of concussion education for coaches across the United States—reaching millions of youth sports coaches over the last decade. These materials focus on concussion symptom identification, response, and management (e.g., return to school and sports), while also addressing the importance of communicating to athletes and their families about concussion safety. The purpose of this study was to assess the effectiveness of CDC HEADS UP materials on coach knowledge and communication with youth athletes about concussion safety. This is the first randomized control study of the CDC HEADS UP materials in real world youth sport conditions. Participants were 764 unique coaches at 15 YMCA associations. Cluster randomization was used to assign branches within associations to the intervention (CDC HEADS UP) and control (treatment as usual) conditions. Coaches completed surveys prior to and at the end of the competitive season. Communication with athletes about concussion increased among coaches in the intervention group (aRR=1.24, 95% CI=1.14, 1.36) but not the control group (aRR=1.09, 95% CI=0.90, 1.31), in multivariate analyses controlling for coach demographic characteristics and baseline communication practices. Concussion symptom knowledge and communication intentions also significantly increased in the intervention group but not in the control group. This study provides evidence that CDC HEADS UP materials increase the likelihood that youth sport coaches communicate with their athletes about concussion safety. As youth sports organizations increasingly mandate concussion education for coaches, CDC

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HEADS UP materials may be considered a leading resource for adoption and setting-relevant implementation.

Keywords

brain injury; concussion; sport; coach education

Pediatric concussions are among the most prevalent injuries in youth sports that involve routine contact or collision.¹ Appropriate management, which includes immediate removal from play for medical evaluation,² is critical for reducing re-injury during a period of heightened vulnerability to both brain and musculoskeletal injury^{3,4} and has been associated with shorter duration of clinical recovery.⁵ Problematically, many athletes continue play while experiencing concussion symptoms.⁶ Many of the most common symptoms of concussion, such as headaches or dizziness, are not readily visible by observers on the sidelines of games or practices. Consequently, early removal from play often relies on athlete self-report to a coach or other adult.

Key determinants of symptom self-report are perceived norms and expectancies about the relational and athletic consequences of care seeking.⁷⁻⁹ Coaches play a central role in shaping these cognitions.^{7,10-13} One key way is through their direct verbal communication about concussion safety, including by sharing concussion education materials and verbally reinforcing educational content.^{14,15} Proximally, this communication can increase athlete knowledge about concussion. However, it is arguably more important as an indicator of the extent to which the coach values concussion safety, and the likelihood that care seeking will be positively reinforced.¹⁶

Recognizing the centrality of coaches in concussion safety, most sports organizations require that they complete some form of concussion education.¹⁴ The most widely used are the Centers for Disease Control and Prevention (CDC) HEADS UP materials.¹⁷ These materials focus on concussion symptom identification, response, and management (e.g., return to school and sports), while also addressing the importance of communicating to athletes and their families about concussion safety. Content analysis of the information shared in the CDC HEADS UP online training for youth sport coaches found that it addressed all key knowledge domains that independent experts deemed important for coaches to engage in concussion safety practices.¹⁴ The most comprehensive of the CDC HEADS UP resources are the online trainings for youth and high school sports coaches. During a recent one-year period the youth sport coaches training was completed by at least 187,801 coaches.¹⁸ Content is also shared in a variety of other modalities, including fact sheet handouts, stickers for coach clipboards, and posters.¹⁷ Such resources can function as reminders, or cues to action, when supplementing the online trainings.

The CDC HEADS UP online trainings for high school and for youth sport coaches contain embedded pre- and post-tests; among the 666,026 high school coaches who completed this course between 2010 and 2013, a significantly higher proportion of coaches answered concussion knowledge questions correctly at post-test as compared to pre-test.¹⁹ A study of the CDC HEADS UP youth sport coaches training conducted between 2016 and 2017

similarly found that among the 179,469 youth sport coaches who completed the online training, there were immediate improvements in knowledge, attitudes, and safety-related behavioral intentions.²⁰ In another study, youth sport coaches who were mailed the CDC HEADS UP materials (fact sheet, clipboard, magnet, poster, and quiz) self-reported that having reviewed the materials they now viewed concussions as being a more serious injury, believed they would be better able to identify a concussed athlete, and had educated others about the injury.²¹ In a different sample, high school coaches who ordered the CDC HEADS UP coach toolkit (video, clipboard sticker, wallet card, and guide for coaches) were mailed a survey; these coaches self-reported improvements in their knowledge, attitudes and safety-related practices.²² In sum, these data support the efficacy of the CDC HEADS UP materials. However, we note that prior evaluations among coaches have been highly limited methodologically, with non-randomized designs, no control groups, most with post-tests conducted immediately after completion of the intervention, and no studies have examined behavioral outcomes.^{20,21,23,24}

Importantly, no rigorous evaluations of the CDC HEADS UP youth sport coach materials to-date have assessed effectiveness in real world youth sport conditions. We note that the CDC HEADS UP youth sport materials for coaches are discrete products (i.e., handout, stickers, online training), and are not accompanied by a cohesive implementation strategy. This allows for setting-specific flexibility for sports organizations to share materials with coaches in the way that fits with setting-relevant communication channels, preferences, and resources. Youth sports tend to have a top-down structure, with a national or regional administrative body providing guidance and resources to local organizations; local organizations are then responsible for disseminating materials to coaches and supporting their implementation. Agents at each level (i.e., national, regional, local) may appropriately tailor *how* CDC HEADS UP youth sports materials are shared with coaches, presuming *core components* of the intervention are not modified. The goal of the present study was to evaluate the effectiveness of the CDC HEADS UP youth sport coach materials in increasing coach communication to youth athletes about concussion safety across a sports season in a common youth sport setting in the United States.

Methods

Organizational setting

This study occurred in United States-based YMCAs. YMCAs are a youth serving organization with locations worldwide that provide low-cost competitive youth sports opportunities. In the United States, more than 4 million youth participate in activities sponsored by the YMCA. The YMCA has a national office that is responsible for setting the general mission, policies, and overhead structure for the semi-autonomous local YMCA Associations and their subordinate branches. About 2,400 regional “associations” typically oversee several local “branches.” Associations have responsibility for oversight, training, local policy implementation, and resource support and allocation. Associations oversee siloed activities across branches (e.g., the association sports director oversees the activities of all branch sports directors). Branches directly implement programming, managing day-to-day operations. At the time this study was conducted, there was no required YMCA

policy related to coach education about concussion. Key stakeholders involved in study implementation at the national level were the national sports director and a representative from associations; the national sports director is responsible for planning, overseeing and supporting sports programs at YMCA associations across the country. At the association level, stakeholders were Association Directors and/or Sports Directors, and at the branch level they were Sports Directors or Volunteer coordinators; the coaches are volunteers at all YMCA branches.

Intervention and implementation strategy

Intervention.—The intervention had four core components, all of which used CDC youth sport materials: (1) CDC HEADS UP online training for coaches to be completed by all coaches prior to the start of the competitive season; (2) supplementary CDC HEADS UP resources (poster, sticker, clipboard, fact sheet); (3) eight weekly CDC HEADS UP messages for coaches to discuss with their athletes; (4) guidance for how local organizations can integrate HEADS UP resources and messages with existing YMCA “Values” resources through existing communication processes, including e-newsletters and the visual message board at the front desk of all YMCA branches.

Implementation strategy.—YMCA administrative leaders at a national level developed an approach to supporting implementation of the CDC HEADS UP youth sport coach materials that was relevant to the YMCA’s organizational structure. Key considerations for implementation included: the importance of incorporating CDC HEADS UP materials into branch-level safety protocols and practices; the need to allow for branch-level flexibility in how and when materials were shared with coaches; and the need to minimize the administrative asks of the volunteer coaches by having branch administrative staff work in tandem with and support coaches with implementation. Elements of the YMCA’s approach to implementing CDC HEADS UP coach education are outlined below.

Local adaptation.—Local organizations made decisions about where to hang the CDC HEADS UP poster for maximum impact, how to share information with coaches about completing the CDC HEADS UP online training, and how and when to follow-up with coaches about their implementation of the CDC HEADS UP materials, including the eight weekly conversation prompts. Local organizations also made decisions about how to incorporate CDC HEADS UP content into their YMCA “Values” materials and communications.

Reminders.—In the intervention condition, YMCA administrators at the branch level sent email reminders and held intercept meetings on practice fields and at games with volunteer coaches as well as YMCA sports administrative staff. The goal of this communication was to check in with coaches about using the CDC HEADS UP materials to talk about concussion safety with their athletes.

Technical assistance.—The research team held weekly technical assistance calls with each association and offered on-demand individual technical assistance appointments. Intervention materials were delivered to intervention condition branches.

Sample and randomization

Participants were volunteer coaches at 15 YMCA associations in the United States. Associations were eligible to participate if they had two or more branches, and if they sponsored competitive male and female sports teams for youth ages 12-17. Associations applied to participate in the project, with eligibility adjudicated by the project YMCA team members. Where possible, randomization occurred at the branch level, and was used to assign branches within associations to the intervention and control conditions. Branches competing against each other were randomized to the same condition to limit the possibility of contamination (e.g., seeing CDC HEADS UP posters in gyms and locker rooms, overhearing pre-game discussions by intervention coaches). In three associations, there were multiple branches but only one league and all teams played their games at a single facility. At these associations, all branches were assigned to the intervention condition.

Data collection procedure

Across both conditions, coaches completed surveys prior to the start of the competitive season (before intervention branches had received any CDC HEADS UP materials), and at the end of the season. Branch sports directors facilitated survey data collection primarily by distributing an online survey link. Paper surveys were also an option, and coaches who indicated a preference for paper surveys were provided with an envelope addressed to the research team that included postage. Up to 5 reminders were emailed to coaches at each branch at each data collection time point. Coaches received \$45 compensation for their participation in survey data collection (\$20 for the baseline survey and \$25 for the post season survey). To facilitate matching baseline and post-season responses, coaches provided their first name, age, zip code and the street number of their dwelling. FHI 360 Protection of Human Subjects Committee approval (884643-5) was obtained for all study activities.

Measures

Communication behavior.—Coach communication with athletes about concussion in the prior season was a constructed variable that combined coaches' responses to three questions about their actions while at the YMCA during this past season. The questions were: Did you have a meeting with your athletes about concussion safety? (yes/no); Did you review with your athletes the YMCA's rules for dealing with concussions? (yes/no); How often did you speak informally with athletes on your team about concussion safety? (Never/Occasionally/Frequently). If a coach said, 'Yes' or Occasionally/'Frequently' to these questions they were classified as having communicated with athletes about concussion during the prior season.

Communication intentions.—Coaches indicated how likely they would be to engage in two communication practices in the future: "Hold a meeting to talk to my team about concussion safety" or "Talk informally to my team about concussion safety". Each question was scored on a 4-point Likert Scale (1="Very unlikely", 2="Somewhat unlikely", 3="Somewhat likely", 4="Very likely"), and the two responses summed to create a scale with a possible range of 2-8.

Concussion knowledge.—Questions separately assessed knowledge about two topics addressed in the CDC HEADS UP educational materials for coaches: concussion identification and concussion management. Eleven questions about concussion identification had the following prompt: “If someone falls, get bumped or gets hit, which of the following can be signs of a concussion.” Examples of symptoms included headache or pressure in the head, and balance problems or dizziness. Items were scored as true (1) or false (0), generating an index with a possible range of 0-11 where higher scores indicate more knowledge about injury mechanisms and symptoms. Knowledge about concussion management was assessed by six scenario-based questions, with coaches indicating whether they “should” engage in the specific behavioral practices, such as allowing an athlete who sustained a possible concussion to keep playing in a game. Response options were on a 4-point Likert scale, ranging from “Definitely should not” (1) to “Definitely should” (4), summed to create concussion management knowledge index with a possible range of 6 to 24, where higher scores indicated more knowledge about concussion management practices addressed in the CDC HEADS UP educational materials for coaches.

Perceived YMCA administrator norms.—Coaches responded to 3 questions about what their YMCA administrators would want them to do (1=“Strongly disagree”, 2=“Somewhat disagree”, 3=“Somewhat agree”, 4=“Strongly agree”) related to concussion management. The total numbers were summed to create a scale with possible range of 3-12, where higher values indicate perceived norms more supportive of concussion management practices consistent with CDC HEADS UP guidance.

Exposure to non-intervention concussion information.—Coaches in both the intervention and control groups also indicated the types of concussion information they had been exposed to separate from the intervention, which included: online training; poster; fact sheet; quiz; website information; an app; movie or documentary; TV show; presentation or talk; book, magazine or other print material; and social media. These items reflected the different modalities of CDC HEADS UP resources, supplemented by other frequently used approaches to concussion knowledge translation.²⁵ The number of different modalities of education to which the coach was exposed was summed to create an index with a possible range of 0 to 11.

Additional covariates.—Potential covariates measured were coach demographic characteristics (sex, race and ethnicity, highest level of education completed), whether they were a first-time coach (Yes/No), whether they had ever been diagnosed with a concussion (Yes/No), and level of contact in the sport they coached. Level of contact was classified as a high contact sport if their team played basketball, soccer, or football in the previous 12 months; all other sports were classified as non-high contact.

Analysis

The primary goal of the study was to determine whether there was increased communication about concussion safety among coaches who were exposed to the intervention. Time was included in bivariate and multivariable analyses to assess change in the primary outcome variable (coach communication behaviors) pre- vs. post-intervention. We conducted

descriptive analyses as well as bivariate and multiple regression analyses to assess whether the proportion of coaches who had communicated with athletes about concussion improved from pre- to post-intervention periods. A bivariate model was first applied, including only a single variable at a time to assess associations with the outcome variable. Since more traditional levels such as 0.05 can fail in identifying variables known to be important, we chose a P-value cut-off point of 0.20 as a first step.^{26,27} All candidate variables that had P-values ≤ 0.20 in the bivariate models were entered into the multivariable model. Analyses were conducted separately for the intervention and the control groups. Similar methods were employed to assess change pre- to post-intervention for secondary outcomes (coach knowledge about concussion, perceptions that YMCA administrators want them to communicate about concussion, and intentions to communicate with their athletes about concussion safety).

Subsequently, we sought to identify additional factors that were associated with communicating with athletes about concussion safety. Analyses were conducted using a similar approach to multivariate model specification as described above, and included both as independent variables coach demographic characteristics, exposure to non-intervention sources of concussion information, and the secondary outcomes as they were theorized to be causally related to coach communication (e.g., coach knowledge about concussion).

Across models, the analytic intent was to measure within-person changes in survey responses across the two time points. However, due to the low number of coaches who completed both the pre- and post-surveys, we used a cross sectional analysis approach with generalized estimating equations [GEE] repeated measures to account for the correlation among matched participants and a potential cluster effect for YMCA associations. A robust Poisson model with sandwich standard error estimator generated by GEE was used to estimate the risk ratios (RR) in the bivariate models and adjusted risk ratios (aRR) in the multivariable models.²⁸ A sensitivity analysis was conducted at the individual level with the smaller subset of coaches who had full data.

Results

There were a total of 1168 observations (pre=725, post-intervention=443) from our survey collected from 75 branches within 15 YMCA associations. From the total observations, 220 were removed because there was no valid answer for the question on ever talked to your team about concussion (Figure 1). A total of 537 coaches completed pre-season surveys (n=432 in the intervention condition and n=105 in the control condition), and 411 completed post-season surveys (n=295 in the intervention condition and n=116 in the control condition). A total of 184 coaches (intervention=148, control=36) participated in both pre-season and post-season surveys.

Overall, demographic characteristics were similar between intervention and control groups (Table 1). Most of the coaches who participated were male, had completed an undergraduate degree, and were not a first-time coach; however, coaches in the intervention condition were more likely to coach a high contact sport. Eighty-six percent of coaches in the intervention

condition and 68% in the control condition reported in the post intervention survey that they had communicated with their athletes about concussion safety.

At the end of the season, the number of coaches who had communicated with athletes about concussion safety increased 50% in the intervention group (RR=1.50, 95% CI=1.37,1.64), but not in the control group (RR=1.13, 95% CI=0.96, 1.32) (Table 2). First time coaches or coaches with higher concussion symptom knowledge scores were more likely to communicate with their team about concussion than more experienced coaches or coaches with lower concussion symptom knowledge scores, respectively in the intervention group ($p<0.001$). In both the intervention and control group, concussion safety communication was more likely among nonwhite coaches ($p<0.02$), coaches exposed to more types of non-intervention concussion materials ($p < 0.001$), and coaches who had stronger pre-season intentions to communicate with athletes about concussion safety ($p<0.001$).

Multivariable analyses found an increased likelihood of communicating with athletes about concussion in the intervention group (aRR=1.24, 95% CI=1.14, 1.36) but not the control group (aRR=1.09, 95% CI=0.90, 1.31) (Table 3). In both the intervention and control groups, exposure to a greater number of different types of non-intervention concussion materials ($p<0.001$) and stronger pre-season concussion safety communication intentions ($p=0.004$) were both significantly associated the coach communicating about concussion safety.

Results of a sub-analysis of the 184 coaches who had participated in both pre-season and post-season surveys (a total of 368 observations, intervention=296, control=72) were consistent with the above multivariable analyses. Because of the small sample size of the sub-analysis data, we only included those covariates which were significant in table 3. At post-season, the percentage of coaches who had ever talked to their team about concussion increased significantly in the intervention group (aRR=1.14, 95% CI=1.01,1.29, $p<0.05$), but not in the control group (aRR=1.09, 95% CI=0.81,1.46, $p=0.576$) (Table 4). In both the intervention and control groups, exposure to a greater number of different types of non-intervention concussion materials and communication intentions were both significantly associated ($p<0.05$) with communicating about concussion.

We also assessed whether there were changes in secondary outcomes as a result of the intervention exposure. Concussion symptom knowledge ($p=0.014$) and communication intentions ($p<0.001$) both had small but statistically significant increases in the intervention group but not in control group (Table 5). Exposure to a greater number of types of non-intervention concussion materials was associated with greater communication intentions in both groups ($p<=0.0001$), and greater concussion symptom knowledge in the intervention group only ($p<0.0001$).

Discussion

YMCA youth sport coaches who received CDC HEADS UP materials were more likely to talk to athletes on their team about concussion safety during the competitive season than coaches who did not receive these materials. Significant change was also observed

in proximal intervention targets of the CDC HEADS UP materials, including concussion symptom knowledge and communication intentions. CDC HEADS UP materials are the most widely adopted form of concussion education for coaches, and the present results provide confidence that they are having a positive impact. In the post-season survey, 86% of coaches in the intervention group reported having talked about concussion safety with their team during the recently completed season (as compared to 68% in the control condition). This is approaching levels observed in U.S. college coaches: nine out of ten college coaches reported having talked to their team about concussion safety in the prior year.²⁹ Health, safety, and educational practices tend to be more robust in U.S. collegiate sport than at the youth level,³⁰ making the relatively higher level of college coach engagement in safety-related communication not surprising. CDC HEADS UP resources, when implemented in a setting-relevant manner, can help bring youth sport coaches in line with their collegiate peers when it comes to their concussion safety-related communication.

Whereas prior studies have assessed the efficacy of the CDC HEADS UP materials when implemented in a highly controlled manner by the research team,^{20,21,23,24} the present study sought to assess the effectiveness of these materials when implemented more naturalistically by a youth sports organization. We note that there are a number of different CDC HEADS UP resources for coaches, and no established guidance on how to share them with organizations and coaches, or how they can be adapted to fit with organization-specific needs, resources, and dissemination channels. Consistent with guidance that all studies should robustly describe the process through which interventions are implemented,³¹ we detailed this information in the present study. The present implementation strategy, including local adaptation, reminders, and technical assistance may not be relevant for all youth sport settings. However, sharing guidance on the CDC HEADS UP website about potential approaches to implementation, and the importance of implementation planning, could strengthen the fit between the intervention and local organizations, ultimately increasing adoption, maintenance, and effectiveness.

Explicit and visible engagement of local organizations in sharing messaging and incorporating the intervention into existing processes and priorities is important for shaping perceptions that implementation is valued organizationally.³² Thus, explicit attention to how CDC HEADS UP materials are implemented could enhance the impact of this effective, and widely adopted educational resource for coaches.

Among coaches in the intervention condition, first time coaches were more likely than more experienced coaches to have communicated with their team about concussion. It is possible that this is an artifact of the coach's age; prior research among college coaches finds that younger coaches have attitudes more supportive of concussion safety, and younger coaches are more likely to communicate with athletes about this topic than their older peers.³³ This could reflect a generational shift towards concussion safety being taken more seriously. It is also possible that experiential learning across prior sport seasons where concussion education was not required, and communication with athletes not encouraged, contributed to ingrained behavioral patterns, and beliefs about what is beneficial or normative in terms of coaching practices. Tailored messaging, or implementation support, may be warranted for older and/or more experienced coaches and may be explored within the context of

CDC HEADS UP resources and implementation guidance for sports organizations. The impact of other coach characteristics on their communication practices warrants further study in larger samples that are adequately powered for sub-group analyses. Findings of differences between white and non-white coaches in the present study should not be over-interpreted given the limited sample size and lack of a prior hypotheses related to race and ethnicity. Nonetheless, it raises questions about whether there are social determinants of sport experiences (e.g., types of sports played, injury and healthcare experiences) that shape how coaches approach the topic of concussion.

We note that many coaches were exposed to concussion education materials other than the CDC HEADS UP resources; on average coaches were exposed to between 5 and 6 different educational modalities. Such exposure may occur informally and passively (e.g., social media), or actively (e.g., searching for information of interest), or through formal requirements in other settings and roles (e.g., education received as a parent of a youth athlete). Coaches who were exposed to more educational resources had greater communication intentions and increased likelihood of communicating with the athletes about concussion safety. Concerns have been raised that not all information about concussion, particularly as communicated in the popular media, accurately characterizes the current evidence-base.³⁴ However, the positive association observed in the present study suggests that overall more exposure may be beneficial. We caution that there may well be a selection effect, in that coaches seek out more information about concussion because they are informed, and think it is an important topic to address with their athletes, rather than the other way around. Directionality notwithstanding, future research on the effectiveness of concussion education may situate the evaluation of discrete educational resources in the broader universe of information about concussion to which coaches are exposed. This could mean taking similar analytic steps as in the current study (i.e., accounting for different exposure to non-intervention educational materials).

Limitations

Primary limitations of this study were that rates of survey completion were low, few coaches completed both pre- and post-test surveys, and there was less participation and more loss to follow-up in the control condition. This limits the generalizability of findings to all YMCA youth sport coaches. Future evaluation studies may benefit from an active control condition to strengthen engagement by control branches. YMCAs are common site for youth sport participation in the United States, but may have unique features that limit generalizability to other youth sport settings such as highly competitive travel sports teams. Further research is needed to evaluate the CDC HEADS UP materials in other youth sport settings. An additional limitation is that the primary behavioral outcome was coach communication behavior, but not athlete concussion reporting behavior. A strengthened approach to evaluation would include a multilevel framework, assessing whether exposure to CDC HEADS UP materials is associated with change in athlete behavior, and looking at mediation by athlete report of formal and informal, verbal and non-verbal coach communication about concussion safety and what types of behaviors are valued on their team. Such an approach would help mitigate socially desirable responding by coaches about their communication practices. We note that coaches were asked *whether* they

communicated about concussion safety, but there may have been a high degree of variability in how they communicated. Further study is needed to understand the nature of impactful coach communication about concussion safety.

Conclusion

This study provides evidence that CDC HEADS UP youth sport materials increase the likelihood that youth sport coaches communicate with their athletes about concussion safety. As youth sports organizations increasingly mandate concussion education for coaches, CDC HEADS UP materials may be considered a leading resource for adoption and setting-relevant implementation.

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Abbreviations:

CDC	Centers for Disease Control and Prevention
GEE	generalized estimating equations
RR	risk ratios
aRR	adjusted risk ratios

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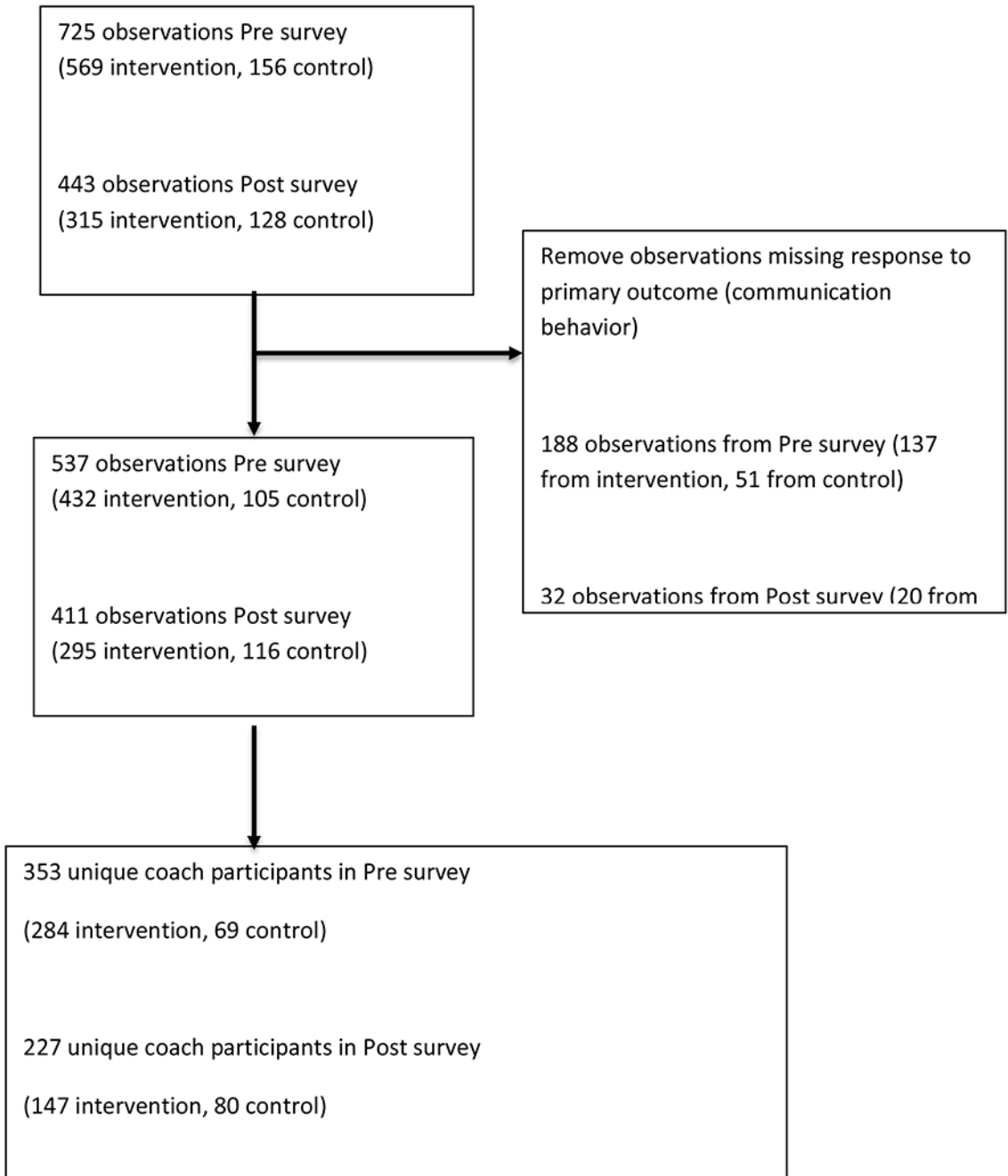


Figure 1. Derivation of coaches in intervention/control group from pre/post intervention survey of evaluation study from the CDC HEADS UP Concussion Initiative in Youth Sports.

Characteristics of coaches who received the Centers for Disease Control and Prevention HEADS UP materials by intervention and control groups*

Table 1.

Variables	Pre intervention (N=537)						Post intervention (N=411)						
	Intervention			Control			Intervention			Control			P Chi-square
	N	%		N	%		N	%		N	%		
Total	432		105				295				116		
Sex													
Missing	7	1.62											
Male	353	81.71	80	76.19	0.111		234	79.32	82	70.69			0.058
Female	72	16.67	25	23.81			61	20.68	34	29.31			
Education													
Missing	7	1.62			0.00								
<= High school, some college or associates degree	124	28.70	30	28.57			97	32.88	41	35.34			0.389
Undergraduate degree	162	37.50	40	38.10	0.975		104	35.25	45	38.79			
Graduate degree	139	32.18	35	33.33			94	31.86	30	25.86			
Race and Ethnicity													
Missing	64	14.81	3	2.86			1	0.34					
White non-Hispanic	246	56.94	68	64.76	0.225		191	64.75	70	60.34			0.346
Hispanic, Black non-Hispanic, Other non-Hispanic#	122	28.24	34	32.38			103	34.92	46	39.66			
Sport coached													
Missing	10	2.31	0	0.00			2	0.68	0	0.00			
All other sports	21	4.86	23	21.90	<0.001		19	6.44	27	23.28			<0.001
Basketball, Soccer, Football (High Contact)	401	92.82	82	78.10			274	92.88	89	76.72			
First year coach													
Missing	3	0.69	2	1.90			2	0.68	1	0.86			
No	421	97.45	101	96.19	0.893		231	78.31	86	74.14			0.351
Yes	8	1.85	2	1.90			62	21.02	29	25.00			

Variables	Pre intervention (N=537)						Post intervention (N=411)						
	Intervention			Control			Intervention			Control			P Chi-square
	N	%		N	%		N	%		N	%		
Coach had a prior concussion diagnosis	No	348	80.56	86	81.90	0.726	247	83.73	100	86.21	0.472		
	Yes	84	19.44	19	18.10		48	16.27	16	13.79			
Communication with athletes about concussion safety	No	186	43.06	41	39.05	0.411	41	13.90	37	31.90	<0.001		
	Yes	246	56.94	64	60.95		254	86.10	79	68.10			
		Mean	STD	Mean	STD	P TTest	Mean	STD	Mean	STD	P TTest		
Exposure to non-intervention sources of concussion information ¹		5.52	0.14	5.7	0.3	0.591	6.66	0.15	6.11	0.24	0.052		
Concussion identification knowledge ²		8.46	0.06	8.51	0.11	0.696	8.7	0.07	8.27	0.14	0.006		
Concussion management knowledge ³		15.91	0.15	16.41	0.29	0.129	16.28	0.17	15.76	0.3	0.132		
Perceived YMCA administrator norms ⁴		11.21	0.08	11.25	0.14	0.781	11.46	0.09	11.29	0.14	0.336		
Intentions to communicate with athletes about concussion safety ⁵		6.44	0.07	6.4	0.15	0.811	7.04	0.07	6.61	0.14	0.006		

* Out of 948 observations, there were 764 unique participants; 184 took part in both pre/post intervention survey.

STD-standard deviation of mean.

¹ Refers to an index with a range of 0-11 reflecting the number of non-intervention sources of concussion education to which the coach has been exposed (e.g., handout, video)

² Refers to an index with 11 true or false questions about concussion symptoms. Values range from 0 to 11 and higher scores indicate more knowledge relevant to concussion identification.

³ Refers to an index with six scenario-based questions, with coaches indicating whether they “should” engage in the specific behavioral practices. Values range from 6 to 24, where higher scores indicated more knowledge about concussion management.

⁴ Refers to coach responses to 3 questions about what they think YMCA administrators would want them to do related to concussion management. Values range from 3-12, with higher scores reflecting perceived norms more supportive of concussion management practices consistent with CDC HEADS UP guidance.

⁵ Refers to whether the coach plans to speak to their team about concussion safety. Values range from 2 to 8 with 8 representing the greatest intentions to communicate with their team about concussion safety.

Table 2. Factors associated with communication with athletes about concussion safety among coaches who received the Centers for Disease Control and Prevention HEADS UP materials by intervention and control groups*

Variables	Intervention						Control						
	Communication behavior (N=727)						Communication behavior (N=221)						
	Yes (N=500)		No (N=227)		RR (95% CI)		Yes (N=143)		No (N=78)		RR (95% CI)		
N	%	N	%		P	N	%	N	%	N	%	P	
Pre/post intervention													
(Baseline)	246	49.20	186	81.94			64	44.76	41	52.56			
(Post intervention)	254	50.80	41	18.06	1.50 (1.37, 1.64)	<0.001	79	55.24	37	47.44	1.13 (0.96, 1.32)	0.159	
Sex													
Male	405	81.49	182	81.61			105	73.43	57	73.08			
Female	92	18.51	41	18.39	1.01 (0.89, 1.15)	0.882	38	26.57	21	26.92	1.01 (0.8, 1.27)	0.932	
Race and Ethnicity													
White non-Hispanic	294	63.09	143	72.96			80	56.34	58	76.32			
Hispanic, Black non-Hispanic, Other non-Hispanic#	172	36.91	53	27.04	1.13 (1.02, 1.25)	0.020	62	43.66	18	23.68	1.28 (1.05, 1.56)	0.016	
Education													
<= High school, some college or associates degree	154	30.99	67	30.04			50	34.97	21	26.92			
Undergraduate degree	176	35.41	90	40.36	0.95 (0.83, 1.08)	0.426	52	36.36	33	42.31	0.89 (0.7, 1.12)	0.582	
Graduate degree	167	33.60	66	29.60	1.03 (0.91, 1.16)	0.426	41	28.67	24	30.77	0.9 (0.7, 1.17)	0.582	
Sport coached													
All other sports	24	4.85	16	7.27			27	18.88	23	29.49			
Basketball, Soccer, Football (High Contact)	471	95.15	204	92.73	1.16 (0.89, 1.51)	0.233	116	81.12	55	70.51	1.21 (0.9, 1.64)	0.179	
First year coach													
No	436	87.90	216	95.58			119	84.40	68	88.31			
Yes	60	12.10	10	4.42	1.29 (1.15, 1.44)	<0.001	22	15.60	9	11.69	1.10 (0.86, 1.42)	0.465	
Coach had a prior concussion diagnosis													

Variables	Intervention										Control									
	Communication behavior (N=727)										Communication behavior (N=221)									
	Yes (N=500)			No (N=227)			RR (95% CI)				Yes (N=143)			No (N=78)			RR (95% CI)		P	
	N	%	STD	Mean	STD	%	N	%	STD	Mean	RR	95% CI	N	%	STD	Mean	STD	RR	95% CI	P
	No	404	80.80		191	84.14							115	80.42		71	91.03			
	Yes	96	19.20		36	15.86							28	19.58		7	8.97			0.064
		Mean	STD	Mean	STD	RR(95%CI)	P						Mean	STD	Mean	STD	RR(95%CI)	P		
Exposure to non-intervention sources of concussion information ¹		6.69	0.12	4.43	0.17	1.10 (1.08, 1.12)	<0.001						6.87	0.21	4.15	0.28	1.13 (1.09, 1.18)	<0.001		
Concussion identification knowledge ²		8.69	0.05	8.28	0.09	1.10 (1.05, 1.17)	<0.001						8.34	0.11	8.47	0.16	0.98 (0.92, 1.05)	0.551		
Concussion management knowledge ³		16.19	0.13	15.76	0.20	1.02 (1.00, 1.04)	0.129						16.56	0.25	15.17	0.36	1.06 (1.01, 1.10)	0.011		
Perceived YMCA administrator norms ⁴		11.38	0.07	11.14	0.10	1.03 (0.99, 1.07)	0.130						11.42	0.12	11	0.17	1.03 (0.96, 1.11)	0.437		
Intentions to communicate with athletes about concussion safety ⁵		7.03	0.05	5.93	0.11	1.22 (1.16, 1.28)	<0.001						6.89	0.11	5.8	0.19	1.18 (1.09, 1.28)	<0.001		

N- number of observations; RR - risk ratio; 95% CI - confidence interval; Ref - reference value; STD-standard deviation of mean.

* Percentage or the mean in each cell is computed using the total number of non-missing records as the denominator. In some cases, the respondents had missing data for the covariates

¹Refers to an index with a range of 0-11 reflecting the number of non-intervention sources of concussion education to which the coach has been exposed (e.g., handout, video)

²Refers to an index with 11 true or false questions about concussion symptoms. Values range from 0 to 11 and higher scores indicate more knowledge relevant to concussion identification.

³Refers to an index with six scenario-based questions, with coaches indicating whether they “should” engage in the specific behavioral practices. Values range from 6 to 24, where higher scores indicated more knowledge about concussion management.

⁴Refers to coach responses to 3 questions about what they think YMCA administrators would want them to do related to concussion management. Values range from 3-12, with higher scores reflecting perceived norms more supportive of concussion management practices consistent with CDC HEADS UP guidance.

⁵Refers to whether the coach plans to speak to their team about concussion safety. Values range from 2 to 8 with 8 representing the greatest intentions to communicate with their team about concussion safety.

Table 3. Multivariable analysis: Factors associated with past-season communication with athletes about concussion safety among coaches who received the Centers for Disease Control and Prevention HEADS UP materials by intervention and control groups.*

Variables	Communication with athletes					
	Intervention (n=589)			Control(n=190)		
	aRR	P	aRR	P	aRR	P
Pre/post intervention						
	Pre intervention	ref	ref	ref	ref	ref
	Post intervention	1.24 (1.14, 1.36)	0.0000	1.09 (0.90, 1.31)	0.3752	0.3752
Race and Ethnicity						
	White non-Hispanic	ref	ref	ref	ref	ref
	Hispanic, Black non-Hispanic, Other non-Hispanic	1.04 (0.95, 1.15)	0.3661	1.13 (0.93, 1.36)	0.2196	0.2196
Sport coached						
	All other sports	ref	ref	ref	ref	ref
	Basketball, Soccer, Football (High Contact)	1.07 (0.85, 1.36)	0.5626	1.25 (0.97, 1.62)	0.0846	0.0846
First year coach						
	No	ref	ref	ref	ref	ref
	Yes	1.02 (0.89, 1.16)	0.7917	1.05 (0.79, 1.39)	0.7546	0.7546
Coach had prior concussion diagnosis						
	No	ref	ref	ref	ref	ref
	Yes	1.06 (0.95, 1.18)	0.2788	1.19 (0.97, 1.46)	0.0878	0.0878
Exposure to non-intervention sources of concussion information ¹						
		1.04 (1.02, 1.07)	0.0001	1.07 (1.03, 1.12)	0.0004	0.0004
Concussion identification knowledge ²						
		1.05 (0.99, 1.11)	0.1177	0.97 (0.91, 1.04)	0.3850	0.3850
Concussion management knowledge ³						
		1.00 (0.98, 1.01)	0.5767	1.04 (0.99, 1.08)	0.0905	0.0905
Perceived YMCA administrator norms⁴						
		1.00 (0.97, 1.03)	0.9407	0.99 (0.93, 1.04)	0.6561	0.6561

Variables	Communication with athletes			
	Intervention (n=589)	P	aRR	P
Control(n=190)				
Intentions to communicate with athletes about concussion safety ⁵	1.17 (1.11, 1.23)	0.0000	1.15 (1.05, 1.27)	0.0041

aRR -- adjusted risk ratio; 95% CI -- confidence interval; Ref -- reference value

Added nesting variable to control for people within a specific YMCA.

Bold indicates p-value <=0.05.

- ¹ Refers to an index with a range of 0-11 reflecting the number of non-intervention sources of concussion education to which the coach has been exposed (e.g., handout, video)
- ² Refers to an index with 11 true or false questions about concussion symptoms. Values range from 0 to 11 and higher scores indicate more knowledge relevant to concussion identification.
- ³ Refers to an index with six scenario-based questions, with coaches indicating whether they “should” engage in the specific behavioral practices. Values range from 6 to 24, where higher scores indicated more knowledge about concussion management.
- ⁴ Refers to coach responses to 3 questions about what they think YMCA administrators would want them to do related to concussion management. Values range from 3-12, with higher scores reflecting perceived norms more supportive of concussion management practices consistent with CDC HEADS UP guidance.
- ⁵ Refers to whether the coach plans to speak to their team about concussion safety. Values range from 2 to 8 representing the greatest intentions to communicate with their team about concussion safety.

Sensitivity-Analysis: Factors associated with past-season communication with athletes about concussion safety among coaches who participated in both pre-/post-intervention survey by intervention and control groups

Table 4.

Variables	Communication behavior			
	Intervention (n=296)		Control(n=72)	
	aRR (95% CI)	P	aRR (95% CI)	P
Pre/post intervention				
Pre intervention	ref		ref	
Post intervention	1.14 (1.01, 1.29)	0.030	1.09 (0.81, 1.46)	0.576
Exposure to non-intervention sources of concussion information ¹	1.06 (1.02, 1.09)	0.001	1.10 (1.01, 1.21)	0.035
Intentions to communicate with athletes about concussion safety ²	1.20 (1.11, 1.29)	<0.001	1.17 (1.01, 1.36)	0.043

aRR -- adjusted risk ratio; 95% CI -- confidence interval; Ref -- reference value

Added nesting variable to control for people within a specific YMCA.

Bold indicates p-value <=0.05.

¹ Refers to an index with a range of 0-11 reflecting the number of non-intervention sources of concussion education to which the coach has been exposed (e.g., handout, video)

² Refers to whether the coach plans to speak to their team about concussion safety. Values range from 2 to 8 with 8 representing the greatest intentions to communicate with their team about concussion safety.

Changes in the key proximal intervention targets (knowledge, perceived YMCA admin norms, and intentions) by intervention condition controlled by selected variables

Table 5.

Variables	Concussion identification knowledge ²				Concussion management knowledge ³				Intentions to communicate with athletes about concussion safety ⁴			
	Intervention (n=653)		Control (n=218)		Intervention (n=593)		Control (n=193)		Intervention (n=634)		Control (n=211)	
	aRR (95% CI)	P	aRR (95% CI)	P	aRR (95% CI)	P	aRR (95% CI)	P	aRR (95% CI)	P	aRR (95% CI)	P
Pre/post intervention												
Pre intervention	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Post intervention	1.02 (1.00, 1.04)	0.014	0.98 (0.94, 1.02)	0.262	1.02 (0.99, 1.05)	0.233	0.95 (0.91, 1.00)	0.054	1.07 (1.04, 1.10)	< 0.001	1.01 (0.96, 1.06)	0.705
Race and Ethnicity												
White non-Hispanic	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Hispanic, Black non-Hispanic, Other non-Hispanic	0.95 (0.92, 0.97)	< 0.001	0.95 (0.90, 1.00)	0.054	1.01 (0.97, 1.04)	0.750	1.06 (1.00, 1.12)	0.043	1.09 (1.05, 1.12)	< 0.001	1.07 (1.01, 1.14)	0.023
Coach Sports												
All other sports	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Basketball, Soccer, Football (High Contact)	1.08 (1.01, 1.16)	0.021	1.03 (0.98, 1.09)	0.274	1.06 (1.00, 1.13)	0.036	0.99 (0.93, 1.06)	0.740	1.00 (0.93, 1.07)	0.892	0.97 (0.90, 1.04)	0.376
Prior concussion diagnosis												
No	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Yes	1.00 (0.97, 1.03)	0.843	0.99 (0.94, 1.04)	0.621	0.96 (0.92, 1.00)	0.081	1.03 (0.97, 1.09)	0.390	0.99 (0.94, 1.03)	0.532	0.96 (0.88, 1.04)	0.309
Exposure to non-intervention sources of concussion information /												
1.01 (1.01, 1.01)	< 0.001	1.00 (0.99, 1.01)	0.516	1.00 (1.00, 1.01)	0.167	1.01 (1.00, 1.02)	0.027	1.02 (1.01, 1.02)	< 0.001	1.02 (1.01, 1.03)	< 0.001	

aRR -- adjusted risk ratio; 95% CI -- confidence interval; Ref -- reference value

Added nesting variable to control for people within a specific YMCA. Analyses also conducted for outcome of perceived YMCA administrator norms, no significant change pre-post intervention and no covariates significantly associated with perceived YMCA administrator norms.

Bold indicates p-value <=0.05.

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- 1 Refers to an index with a range of 0-11 reflecting the number of non-intervention sources of concussion education to which the coach has been exposed (e.g., handout, video)
- 2 Refers to an index with 11 true or false questions about concussion symptoms. Values range from 0 to 11 and higher scores indicate more knowledge relevant to concussion identification.
- 3 Refers to an index with six scenario-based questions, with coaches indicating whether they “should” engage in the specific behavioral practices. Values range from 6 to 24, where higher scores indicated more knowledge about concussion management.
- 4 Refers to whether the coach plans to speak to their team about concussion safety. Values range from 2 to 8 with 8 representing the greatest intentions to communicate with their team about concussion safety